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THERMAL AND ELECTRIC BURNS

- USSR -

Following is a translation of Chapter 7 from a Russian-language book, Voenno-Polevaya Khirurgiya (Military Field Surgery), by A. A. Vishnevskiy and M. I. Shroyber, Moscow, 1962.

Thermal Burns

Burns were infrequently encountered in past wars. During World War II they were a significant factor only in certain operations of the ground forces and in combat operations on the sea. In war involving the use of nuclear weapons thermal burns acquire exceptional importance. For example, after the explosion of atomic bombs in Hiroshima and Nagasaki in 1945, about 100,000 persons suffered burns. Some 65% of all the casualties were due to burns (Miller). About half of the deaths from the blasts were caused by burns (Arts, Reiss, and others). Several investigators believe that if nuclear weapons are used, the total number of persons burned (including those with combined injuries) would come to 60 to 85% of the casualties (Crawford, Le Roy, and others).

Burns following a nuclear explosion may be due to the direct action of luminous radiation (primary) or to numerous conflagrations (secondary). Either or both may be combined with mechanical injury and with radiation injury.

Burns from the direct action of luminous radiation (instantaneous, outline burns) arise at a certain distance from the epicenter on the parts of the body facing the blast. Clothing (especially if light in color and loose) provides good protection against such burns, which are most likely to affect exposed parts of the body (face, hands, arms). In the places where the clothing fits tightly, it does not prevent the so-called contact burns. When close to the epicenter, a person can become completely charred due to his clothing catching fire. Secondary burns resulting from an atomic explosion are like ordinary thermal burns.

In modern warfare burns may also be caused by the combustion of incendiary mixtures (e.g., napalm).

Burns are classified (depending on the extent of tissue injury) as first degree, characterized by hyperemia and edema of the skin; second degree, characterized by the formation of blisters on the affected portions of skin filled with a transparent yellowish fluid; third degree, characterized by necrosis of skin, involving only the germinative layer (third degree-A) or all the layers (third degree-B); fourth degree, characterized by necrosis not only of all the layers of skin but of the deeper lying tissues (fascia, tendons, bones, etc.). Victims often have burns of different degrees (Figs. 19, 20).



Fig. 19. Extensive second-third degree thermal burn (personal observation).



Fig. 20. The same patient after treatment.

The actual depth of tissue injury, especially in third-degree burns, cannot, as a rule, be accurately determined until several days after the injury.

Burns are classified as superficial (first and second degrees) and deep (third degree-B and fourth degree) depending on the severity of the course, duration, and final results of treatment. Fourth degree-A burns occupy a position in between the two types.

Superficial burns are very painful. Deep burns, on the other hand, are much less so during the first few hours and days

thereafter because the high temperature destroys the nerve endings. First-degree burns heal within a few days as the horny layer is sloughed off. Pigmentation of the burned area sometimes becomes intensified. In the case of light burns pigmentation may survive for a long time.

Second-degree burns with an uncomplicated course heal in 6 to 14 days by epithelization without scarring. If there is infection and the contents of the blisters suppurate, healing takes place by granulation lasting 3 to 4 weeks and the skin remains scarred.

With deep burns the first phase of the wound process is characterized by suppuration with liquefaction and sloughing off of necrotic tissue. The second phase is characterized by granulation, cicatrization, and epithelization of the defect formed. The time required for healing varies with the extent of the area affected, condition of the organism, and methods of treatment used. More or less substantial defects resulting from deep burns do not heal spontaneously.

Peculiar pigmentation and depigmentation areas may appear after second-third degree light burns heal.

Plasma may exude into surrounding tissues soon after trauma due to impairment of capillarity permeability in the area of the burn. This results in edema, and in the case of second-degree burns the plasma oozes to the surface of the skin.

If the affected area is extensive, the loss of plasma may be considerable, thus seriously endangering the life of the victim.

Burns caused by the action of incendiary mixtures differ from other burns mainly in the greater depth of tissue injury and resultant long period of healing. Napalm burns are often associated with severe (sometimes fatal) carbon monoxide poisoning induced by incomplete combustion of the substances.

If the burned area is heavily contaminated by radioactive substances, their local action is sometimes manifested in enlargement of the necrotic area and slowing of the healing processes. There is little likelihood of the radioactive substances having a systemic effect when absorbed through the burned surface.

Radiation sickness (systemic radiation injury) may seriously interfere with the healing of burns. In second- and third-degree radiation sickness the cleansing and regenerative processes slow up and occasionally cease altogether toward the end of the latent period. Necrotic tissue is not sloughed off for a long time and new necrotic foci appear. Granulation and epithelization are likewise retarded. The meager, flaccid granulations bleed and multiple hematomas form. The absence of a wound barrier and low general resistance of the organism frequently give rise to local and systemic infectious complications.

A combination of second to fourth-degree burns and radiation sickness greatly complicates the course of the disease and worsens the prognosis (A. N. Berkutov, V. A. Polyakov, B. M. Khromov, and others).

The severity of thermal burns is measured both by the depth and by the area involved. The area is determined under field conditions by palm measurement (the palm area constitutes 1 to 1.2% of the body surface) or by the rule of ninths. According to this rule, the head and neck surface constitutes about 9% of the body surface, the surface of one arm - 9%, one leg - 18%, back of trunk - 18%, front - 18%, perineum - 1%.

Second to third-degree burns covering no more than 8 to 10% of the body surface are considered chiefly local involvement. More severe burns regularly cause serious general disorders with the development of burn disease. The course of the latter includes the stages of shock, toxemia, septicotoxemia, and convalescence.

Burn shock as a variety of traumatic shock is a response to a superintense pain stimulus. The erectile phase often turns into a torpid phase in the course of burn shock. Burn shock may last from several hours to two or three days. Its main characteristic is more pronounced (as compared with other types of shock) capillary permeability, which initially embraces the affected area and then becomes generalized. Increased

capillary permeability, as noted above, causes blood plasma to exude through the capillary walls, resulting, if the area is extensive, in hemoconcentration. Second to fourth-degree burns destroy a great many erythrocytes. The pronounced tissue hypoxia in burn shock is believed to be due largely to the impossibility of tissue utilization of oxygen.

The clinical picture of burn shock is quite similar to that in traumatic shock of different origin. Light burns often result in unconsciousness. With marked hemoconcentration the victims may experience severe thirst. Urinary disorders ranging from oliguria to anuria are common.

Burn toxemia imperceptibly follows shock and gradually develops into septicotoxemia (burn sepsis). Intoxication by the incompletely oxidized intermediate metabolic products starts during the shock stage (D. N. Golubnitskiy and P. A. Chevyreva, and others). Poisoning by products of generalized decomposition of protein and protein in the burned tissues and by bacterial toxins aggravates the toxemia. The toxemia period, which lasts 5 to 15 days, is characterized by high temperature, frequent vomiting, brain symptoms (with a prevalence of signs of excitation or inhibition), anorexia, and insomnia. Sopor develops in more severe cases. The septicotoxemia stage is characterized by suppuration of fairly extensive and deep burns. Clinically, burn sepsis often resembles the preceding

stage. Metastases of a purulent infection sometimes develop in patients with burn sepsis. Severely burned persons may develop in the septicotoxemia stage exhaustion, which has a long and stubborn course (Fig. 21) and often ends fatally.



Fig. 21. Burn exhaustion (personal observation).

Symptoms of hypoproteinemia and anemia are pronounced in toxemia and septicotoxemia.

During the course of burn disease, complications may arise in the kidneys (pyelitis, nephritis, nephrosonephritis), lungs (bronchitis, pneumonia, pulmonary edema), digestive organs (acute gastric and duodenal ulcers, hepatitis, etc.), and cardiovascular system (toxic myocarditis, etc.).

In a combat situation, facial burns are often accompanied by burns of the eyes and respiratory tract. In the latter case the patients may suffer from dyspnea, cyanosis, hoarseness (sometimes aphonia), and coughing, unproductive or with foamy sputum. Burns in the upper respiratory tract may cause laryngeal edema and severe asphyxia.

Treatment of Burns

Principles of General Treatment of Extensive Burns

The ordinary antishock therapy is used for burn shock.

A novocain block helps to control the increased capillary permeability. A bilateral paraneural block is particularly effective. While in shock the victim is given an intravenous infusion (over a period of 24 hours) of 3 to 4 liters of the following fluid: banked blood - 250 to 500 ml, plasma (protein blood substitutes) - 250 to 750 ml, dextran - 500 to 1500 ml, physiological salt solution - 1000 to 1200 ml, 0.1% novocain solution - 500 to 600 ml.

The amount of fluid infused and rate of administration are determined by the seriousness of the victim's condition, level of hemoconcentration, and amount of hourly diuresis. Copious drinking of a saline-alkaline solution (a teaspoon of salt and a half teaspoon of baking soda) is prescribed in the absence of vomiting.

Even in the absence of symptoms of shock, antishock therapy is recommended for second to fourth-degree burns covering more than 10 to 15% of the body surface, for it serves as a prophylactic measure.

General treatment of burn victims in the periods of toxemia and septicotoxemia consists of measures designed to combat

intoxication, infection, anemia, and hypoproteinemia, prevention and treatment of other complications, especially in the lungs and kidneys. The victim is given repeated blood transfusions, isogenous plasma, heterogenous protein plasma substitutes (aminopeptide, etc.), infusion of weak glucose and saline solutions, cardiac stimulants, narcotics, soporifics, vitamins (chiefly vitamin C, but also B₁, B₂, B₆, and B₁₂). Proper diet and care are extremely helpful. Antibiotics are effective only during the first ten days after a burn because by this time the microflora of the affected area generally becomes resistant to the substances.

If burns are combined with injury by penetrating radiation, the radiation sickness is treated at the same time.

Principles of Local Treatment of Burns

Initial treatment of second to fourth-degree burns is essentially a matter of cleaning the affected area. The hairs around the burn are shaved and the surrounding skin is cleaned with balls of cotton dipped in ammonia water and then rubbed with ethyl alcohol. The remnants of burned clothing and shreds of skin are removed from the burn surface. Large blisters are incised at the base and evacuated; smaller ones are not touched. The clearly contaminated parts are carefully cleaned with balls of cotton dipped in hydrogen peroxide. The area

is then irrigated with warm physiological solution and dried. This is followed by application of a sterile bandage with A. V. Vishnevsky's balsamid emulsion birch tar - 1 g, anesthesin - 3 g, bismuth tribromophenate - 3 g, castor oil - 100 ml). A streptocide, sulfidin, or synthomycin emulsion or furacilin ointment can also be used.

Initial treatment of burns contaminated by radioactive substances is the same as in the case of noncontaminated burns. It may be carried out in the general dressing room after preliminary medical processing of the casualties. Initial treatment of burns, whether or not contaminated by radioactive substances, is best carried out during the first 24 to 48 hours after injury. However, it can be postponed if there is a great influx of casualties.

A burn should not be treated if the victim shows signs of shock. All that should be done at this time is to apply a dressing, postponing the cleaning until the person is brought out of shock.

If the burn is deep but covers a small area (up to 10 or 12% of the body surface) and the victim's general condition is satisfactory, it is well to remove all the necrotic tissue as soon as the boundary of necrosis is clearly discernible (6th to 9th days). The resultant defect is completely covered with a skin autograft (primary dermatoplasty). This method is

particularly effective for burns combined with radiation lesions because it promotes the healing of the burn wound during the latent period of radiation sickness (P. N. Burenin, E. L. Razgovorov, A. V. Agishev, and others). The necrotic skin is not removed nor is a dermatoplasty performed at the height of the sickness (A. V. Gridnev, L. S. Korchanov, and others).

In the case of extensive burns for which surgical excision of necrotic tissue would be too dangerous, the dead skin is removed bloodlessly in stages at the regular changes of dressings. It is only when the wound is completely clean that a second dermatoplasty is performed, usually in two or more stages.

Homoplastic skin transplants are used to cover broad defects in critically burned persons until they are ready for an autoplasty (Fig. 22). A combined dermatoplasty (simultaneous grafting of auto- and homotransplants in checkerboard fashion) is used if the patient's own skin is insufficient. The operation must be followed by vigorous general therapy. If there is marked anemia or hypoproteinemia, autografts usually do not take.



Figure 22.

In the case of deep circular burns of the extremities covering more than 25 to 30% of the body surface, amputation may have to be performed in order to save the victim's life. This approach is particularly recommended if the burns are combined with radiation sickness or wounds.

A tracheostomy should be performed as soon as possible for burns of the respiratory tract. Transfusion therapy should be employed cautiously in these cases because pulmonary edema may result from too rapid administration of the fluid.

Principles of Stage Treatment of Burns

First aid. Burning clothing, and napalm fire, etc. are extinguished by one of the following methods: throwing an overcoat or poncho over the blaze, throwing snow or earth on it, submerging the burning items in water. Clothing adhering to the burned surface is not removed, but as much of the wound as possible is covered with an aseptic bandage. The victim is allowed to drink some alcohol or injected subcutaneously (with an hypodermic syringe).

Initial medical aid. Tracheostomy performed for burns of the upper respiratory tract. Moderately and severely burned persons injected with morphine. Cardiac stimulants administered as indicated. Aseptic bandages applied. Antibiotics and tetanus antitoxin administered (if circumstances permit). Copious drinking (hot tea, saline-alkaline solution). Immediate evacuation of those in a state of shock.

Qualified surgical aid. Comprehensive antishock therapy for all persons in shock. If there is a delay in evacuation, preventive antishock therapy must be carried out for all those

in whom the affected area constitutes 10 to 15% of the body surface. The first bandages are changed, antibiotics again administered, morphine and cardiac stimulants injected as indicated. Continued drinking of saline-alkaline solution.

In sorting burn casualties, the following are taken into consideration as rough guides (because the sorting is generally done without removing the bandages):

(a) Hospitals for the slightly wounded treat victims with second-degree burns, regardless of site and area affected, or with limited deep burns of the trunk and large portions of the extremities (except the joint region) if the area is no more than 1 to 3% of the body surface, without signs of shock, capable of independent movement and self-care during the first few days after the injury, with a probable period of treatment up to 45 days, and capable of continued military service after recovery;

(b) Specialized hospitals for burns treat severely injured persons with marked symptoms of burn disease until they are able to move about and burned persons capable of returning to duty within no more than 45 days, but who require hospital care;

(c) Specialized and general surgical hospitals treat persons with burns and other injuries according to the principle of the major injury.

Casualties with limited superficial burns, capable of taking care of themselves completely, and with a treatment period up to 10 days may be kept together in groups of convalescents.

At the stage of specialized aid the main tasks are as follows:

1. Treatment and returning to duty of all burn casualties with treatment periods up to 1½ months.
2. Treatment of nontransportable casualties.
3. Preparation for evacuating to the zone of interior all those requiring more than 1½ months of treatment as well as those unsuited for military service after recovery (regardless of length of treatment).*

Radiation Burns

Radiation burns may arise in a combat situation chiefly as a result of irradiation of the skin or mucous membranes with beta particles, which are unable to penetrate very deeply into the tissues. The lesions are usually caused by direct contact between the radioactive substances and the skin. With mixed beta and gamma irradiation local lesions develop against a background of radiation sickness. Four periods are usually distinguished in the course of radiation injury to the skin.

* Sometimes only those who have become completely unsuited for combat or who require prolonged treatment are evacuated to the rear.

The early reaction to irradiation (first period) appears from a few to 24 hours after injury in the form of primary erythema of differing intensity, sometimes accompanied by petechial rashes. The erythema persists from a few hours to two days.

During the second (latent) period there are usually no external manifestations of the injury. In a few victims the skin may redden briefly (in the affected area). The latent period lasts from a few hours to three weeks, depending on the severity of the injury.

Secondary erythema appears in the affected area during the third (acute inflammatory) period. If the injury is severe, blisters develop in one to three days against a background of erythema. They gradually enlarge and partly coalesce. Painful bleeding erosions develop later at the site of opened blisters. If there are patches of deep necrosis, irregularly shaped ulcers with eroded margins and dingy gray fatty base may arise. The third period lasts from two or three weeks to several months, depending on the severity of the process.

The fourth period (regeneration) is characterized by the gradual disappearance of the erythema, resorption of the edema, and healing of the erosions and ulcers. Ulcers have a very sluggish course and they take a long time, sometimes years, to heal. They often recur. The skin of the affected area is

pigmented with some degenerative changes in evidence (atrophy, hyperkeratosis with desquamation, loss of hair, deformity and brittleness of nails). If the burns are deep, trophic disorders extend even to the deep lying layers (muscular atrophy, contractures and ankylosis).

Four degrees of skin injury are distinguished in relation to severity of the course. First-degree burns (minor injury) arise after exposure to a dose of up to 1500 FRE (physical roentgen-equivalents, i.e., the amount of alpha- or beta-radiation yielding on absorption the same quantity of energy as 1 g of gamma radiation). They are characterized by rather insignificant secondary erythema and temporary epilation with little or no perceptible early reaction and by a latent period of more than two weeks. The recovery period takes several months and is featured by desquamation and pigmentation of the skin.

Second-degree burns (moderate injury) arise after exposure to a dose of 1500 to 3000 FRE. The transitory early reaction is more distinct and the latent period lasts less than two weeks. The third period is characterized by marked secondary erythema, sometimes associated with the formation of small blisters. Restoration takes several months. The skin of the affected area suffers trophic disorders for a long time.

Third-degree burns (severe injury) arise after exposure to radiation doses ranging from 3000 to 10,000 FRE. The early reaction appears within a few hours of exposure and lasts up to two days. The brief latent period (three to six days) is followed by the appearance of pronounced secondary erythema, skin edema, recurrent erosions and ulcers that take a long time to heal. Trophic skin disorders are pronounced.

Fourth-degree burns (extremely severe injury) arise after exposure to radiation doses in excess of 10,000 FRE. They are characterized by a rapid and pronounced early reaction, very short latent period (or none at all), and swift onset of the third period. Necrosis is extensive and unusually persistent. Restoration is a lengthy process.

Second to fourth-degree radiation lesions may be accompanied by fever, regional lymphadenitis, and leukocytosis. The affected areas are very painful in the period of acute inflammation.

The prognosis for radiation burns depends on the depth (degree) and area involved.

Principles of Treatment of Radiation Burns

The earliest possible medical treatment of persons exposed to radioactive substances is the most important prophylactic measure. Since trophic disorders are prominent in radiation burns, a brief procaine block is recommended for limited burns

and a lumbar block for extensive burns. Repeated blood transfusions in fractional amounts, administration of antibiotics and vitamins, and use of narcotics are likewise indicated. Salve dressings are applied locally. The blisters are punctured and the contents withdrawn (with strict observance of asepsis). In the case of deep burns, the ulcers are excised at the end of the period of acute inflammation and the resultant defects replaced with free skin autografts or Filatov's graft (Figs. 23, 24). If radiation burns are combined with general radiation injury, the radiation sickness is treated at the same time. Surgical treatment of such burns is resorted to only when the sickness has resolved.



Fig. 23. Fourth-degree radiation burn caused by excessive radiation therapy (personal observation).



Fig. 24. The same patient after excision of affected tissues and covering of defect with a Filatov graft.

Frostbite

During World War I frostbite among the troops constituted 0.92 to 31.6% of all the wounds (V. S. Gamov). During the Soviet-Finnish War of 1939, it made up 8.13% of the total number of medical casualties (P. A. Kupriyanov). In the vast majority of cases it was the lower extremities that were involved. During World War II, frostbite of the lower extremities constituted 91.2% of all cases (V. S. Gamov).

Frostbite may occur even when the temperature is not particularly low or even when above freezing (especially if there are periodic thaws). Other factors play an important part besides the duration of exposure to cold, e. g., humidity, wind, tendency for the feet to perspire, wearing of wet shoes and clothes, impairment of circulation in the extremities (due to tight shoes, trouser strings, puttees wound too tightly, tourniquet), prolonged enforced immobility, e. g., after being wounded, at a "listening post," etc.

The development of frostbite is also promoted by physical and mental fatigue, exhaustion, loss of blood (from wounds), and previous frostbite.

The so-called latent period of frostbite while the affected tissues are still exposed to cold, is characterized by skin pallor in the area, local drop in temperature, and loss of sensitivity. The actual depth and extent of tissue injury cannot be determined until

some time after the action of the cold ceases (sometimes as much as several days later. Under the influence of cold, the injured tissues develop complex trophic disorders. Four degrees of frostbite are distinguished (S. S. Girgolav and T. Ya. Ar'yev).

First-degree frostbite is characterized by a reddish purple-blue color and some edema of the affected skin, itchiness (sometimes very pronounced), paresthesia, and piercing pain in the injured area. All these symptoms disappear in a few days, but the affected area retains increased sensitivity to cold for a long time.

Chilblain is a chronic dermatitis (usually of the fingers) often caused by systematic, repeated, but not severe or prolonged chilling (for example, in persons servicing combat matériel and handling small metal parts). Those who have suffered from frostbite are most prone to develop chilblain. In mild cases the changes are limited to edema, cyanosis, severe itching on warming; in severe cases cracks and ulcers appear on the body of the interphalangeal joints.

Second-degree frostbite give rise to blisters filled with a yellowish or hemorrhagic fluid. Skin edema and disagreeable subjective sensations are usually quite pronounced. Treatment usually requires 10 to 30 days.

Third-degree frostbite is characterized by necrosis of the skin and subcutaneous tissue. Blisters with hemorrhagic contents may form on non-necrotic skin as well. Necrotic tissue undergoes partial liquefaction and desquamation accompanied by suppuration. The resultant defect heals in 30 to 60 days by secondary intention.

In fourth-degree frostbite the underlying soft tissues and bone as well as the skin necrose. The demarcation line usually appears the second week after the frostbite (Fig. 25). A stump is invariably formed after fourth-degree frostbite of an extremity.



Figure 25

A serious variety of fourth-degree frostbite is trench foot, which is characterized by an asymptomatic latent period and gradually developing severe trophic disorders. It arises after prolonged exposure to moderately low temperatures, especially if the shoes are constantly wet.

Frostbite is often complicated by the development of different kinds of purulent infections.

Besides local injury to tissue, the general action of cold on the organism may result in freezing due to exhaustion of the adaptation mechanisms of thermoregulation, when external chilling causes body temperature to fall steadily.

Frostbite can be prevented among troops by a set of measures, including proper fitting and care of shoes, prompt changing from felt to leather boots when it thaws, control of hyperhidrosis, changing and drying of wet foot wear (socks), making hot food available to the soldiers, and draining trenches and dugouts.

Hot water bottles should be used in case of enforced immobility, especially when evacuating the wounded in cold weather in unheated vehicles. Rapid walking, running, brisk movement of the legs and arms when standing on one spot are good means of preventing frostbite or freezing. Drinking a little alcohol also has some prophylactic value. There are no proven ointments to prevent frostbite.

First Aid and Treatment

The victim should be brought into a warm room as soon as possible. During the latent period the frostbitten areas are rubbed with alcohol and gently massaged with clean dry hands until circulation is restored. If circumstances permit, the affected extremities should be submerged in warm water (20°) gradually heated to 30 to 35°. The affected areas are massaged at the same time. After circulation is restored, alcohol is again rubbed on the skin and a dry aseptic bandage applied. If the face is frostbitten, the affected parts are rubbed with a cotton tampon until circulation is restored. The face is usually not bandaged; the skin is smeared with

vaseline oil. In addition to these purely local measures, the victim is given hot tea and food and small amounts of alcohol. All frostbitten persons are given tetanus antitoxin.

The treatment is determined by the degree of frostbite when the latent period is over. In first-degree frostbite the affected area is daubed with a 5% alcohol solution of tannin. A procaine block is used for chilblain. Some chilblain cases are helped by warm baths daily with green soap, but elimination of the cold is the decisive factor. Chilblain disappears spontaneously with the advent of summer.

A procaine block is applied at the root of the extremity for second- and third-degree frostbite. All the blisters are opened and a dressing applied (with Vishnevskiy's oil-balsamic emulsion, synthomycin emulsion). Antibiotics are administered a few days later. Physiotherapy is also useful (oabinet baths, erythema doses of quarts, UHF). The healing time of third-degree frostbite may be shortened by excising the dead tissue (after the boundaries of necrosis are clearly evident).

In the case of fourth-degree frostbite, the dead tissue is excised somewhat beyond the demarcation line (usually by disarticulation). Necrectomy in these cases is facilitated by the formation of an eschar, which may prevent infection from developing. A typical amputation (with suturing of the

skin of the amputation stump) is performed after subsidence of the inflammatory phenomena, which can be accelerated by physiotherapy. It is sometimes desirable to perform a necrotomy several days before removing the dead tissue, i.e., to excise necrotic tissue along the axis of the extremity, a procedure that promotes very rapid drying of the necrotic area. If a serious infection (e.g., anaerobic) develops, the extremity must be amputated without waiting for the inflammatory process to subside or the demarcation line to appear. Amputation is not performed for frostbite solely from primary indications.

If the victim is frozen, he must be brought to a warm place as rapidly as possible, undressed, and covered with hot water bottles (temperature no higher than 40°). If indicated, artificial respiration is carried out, cardiac stimulants administered, and slightly warmed (to body temperature) blood transfused. As soon as the victim becomes conscious, he is given strong hot tea, alcohol, and hot food.

Stage Treatment of Frostbite

First aid. Restoration of circulation in the frozen area (which can be done with dry hand massage if no alcohol is available). Placing dry aseptic bandages on the affected area.

Initial medical aid. Full scale aid for general freezing.

First aid (if not rendered earlier). Injection of tetanus

... and antibiotics for second to fourth-degree frostbite (if circumstances permit). Victims with limited first-degree frostbite are aided and then returned to their units, while the others are later evacuated to the rear (bandages with a thick layer of cotton are placed on the affected area).

Qualified medical aid. Primary treatment for second-degree frostbite (if circumstances permit). Victims with more or less extensive first-degree frostbite or with limited second-degree frostbite that do not prevent free movement about and complete self-care are kept here (in the convalescent group). Evacuation of all the other victims to the rear.

In sorting casualties the following considerations are taken into consideration: (a) all those with second to fourth-degree frostbite, (except those noted above) with treatment periods up to 45 days who are capable of moving by themselves and taking care of themselves and can be returned to duty after recovery are sent to hospitals for the slightly wounded; (b) all other frostbite cases are sent to general surgical hospitals.

Specialized medical aid. Treatment of all casualties with second to fourth-degree frostbite, and treatment up to 45 days of those who can be returned to duty after recovery. Treatment of all nontransportable cases (chiefly with infectious complications).

All other casualties are evacuated to the zone of interior.*

Electric Burns

A distinction is made between the direct and indirect action of electric current on man. The indirect action of a current (by the flame of an electric arc when wires are short-circuited) produces ordinary thermal burns. The direct action of a current, if the victim is included in the electrical circuit or if the current passes through his body into the ground, produces several characteristic general and local changes.

The general changes are due to the effect of the current on the central nervous system. Syncope is characteristic of mild cases. In severe cases deep unconsciousness is associated with sharp weakening of respiration and cardiac activity. Some victims seem to be dead. Death may occur either at the moment of trauma or several hours or even several days later.

Local changes with direct action of the current include the appearance of current marks and electric burns. Current marks are yellowish-brown or whitish spots on the skin with ridgelike infiltration of the margins and depression in the center. Current marks are painless and not associated with reactive vascular phenomena. They are found at the points where the current entered and left the body and where skin folds were encountered along the path of the current.

*In a number of instances only those personnel who are not capable of fighting and those who require lengthy treatment will be evacuated to the zone of the interior.

Electric burns usually produce profound tissue injury (including necrosis of portions of the skeleton). Injury to the blood vessels causes sudden (sometimes severe) hemorrhages (two to three weeks after injury). Otherwise, the course of electric burns is generally quite favorable and the cosmetic and functional after effects are better than with thermal burns.

Principles of First Aid and Treatment

Due to tonic contraction of the muscles, victims are frequently unable to get away from the wire without outside help so that often the first task is to switch off the current. This may be done by cutting the wire with a long-handled shovel or dragging the victim off. In performing these tasks the rescuer must be careful not to come in contact with the wire himself. He should stand on a dry overcoat or wipe his hands with dry rags, use a stick, etc.

First aid, if there are pronounced general phenomena (deep faint, apparent death) should be rendered as quickly as possible, preferably at the site of the accident. Even if the victim shows no signs of life, everything must be done to resuscitate him, chiefly by artificial respiration, which should continue until complete restoration of breathing or appearance of clear signs of death (rigor mortis, cadaveric lividity). Besides artificial respiration, the victim should

be periodically made to sniff ammonia water.

Initial medical aid includes artificial respiration plus periodic inhalation of oxygen, injections of cytisine and cardiovascular stimulants (cardiazol, caffeine, corglycon [preparation containing all Convallaria majalis glycosides], etc.). If the victim has cyanosis due in part to venous congestion in the systemic circulation, venesection must be performed (in the amount of 200 to 400 ml).

If a victim is brought immediately to a facility with qualified medical personnel in a state of collapse or with signs of primary cardiac standstill (the so-called asphyxia pallida), an immediate intraarterial infusion of banked blood is indicated.

After restoration of respiration and cardiac activity, it is better if the victims are not moved for the next few hours because they must be kept under observation (there is a possibility of sudden worsening of the condition or even death). If there are no serious general phenomena, the victims may be immediately evacuated to the stage of specialized medical aid, where treatment is completed.

Local electric burns are treated conservatively at first. A procaine block and bandages with Vishnevskiy's oil-balsamic emulsion, synthonycin emulsion, furacilin ointment) are used.

Antibiotics and vitamins are administered for the first seven to ten days. If indicated, blood, serum, and protein blood substitutes are transfused. A temporary tourniquet is loosely applied to a burned extremity due to the danger of sudden bleeding. Active surgical intervention (excision of necrotic tissue and autograft) is undertaken two to three weeks after the trauma, when the boundary line of necrosis can be clearly discerned and there is no longer any danger of secondary hemorrhage.

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